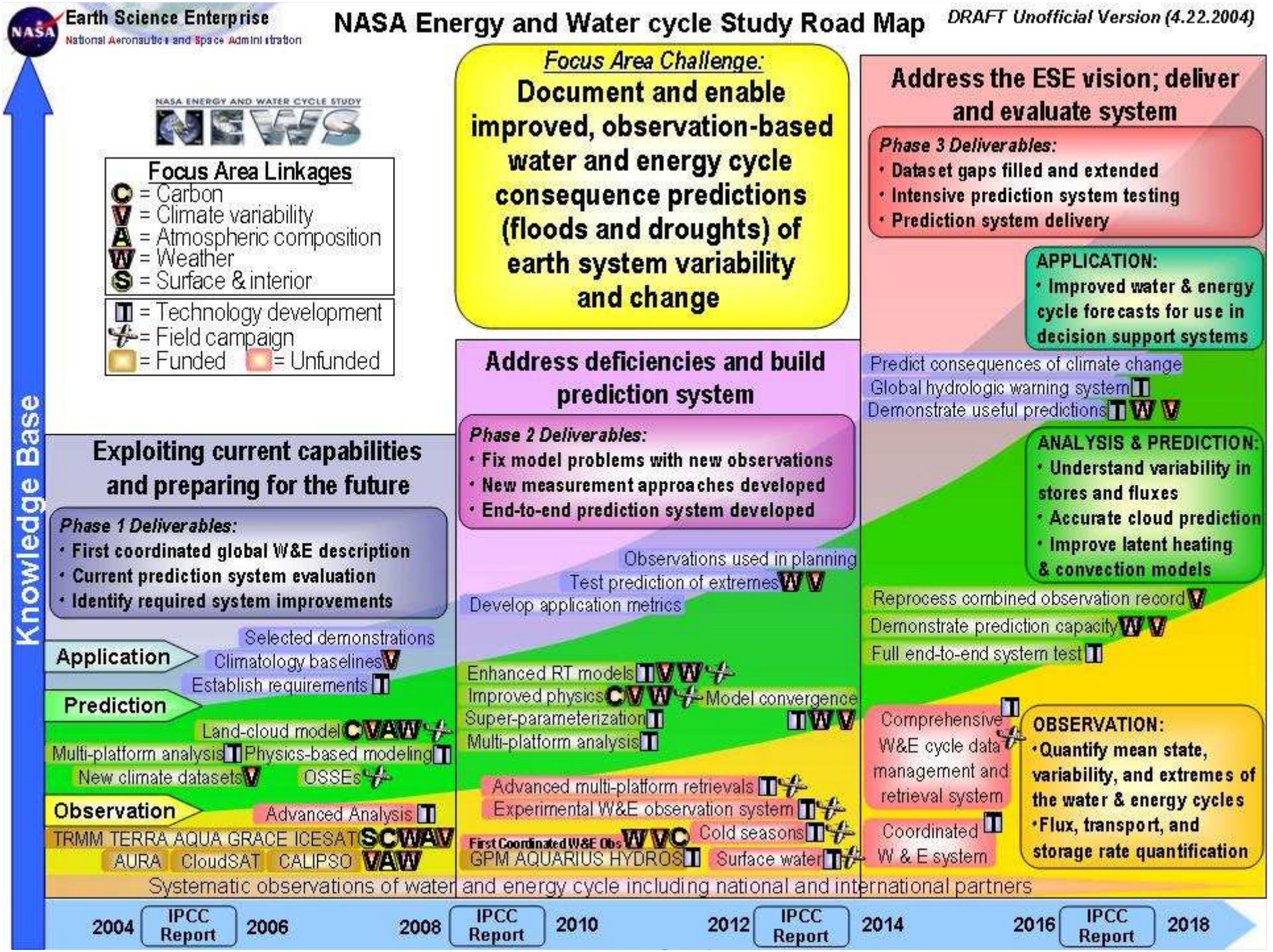
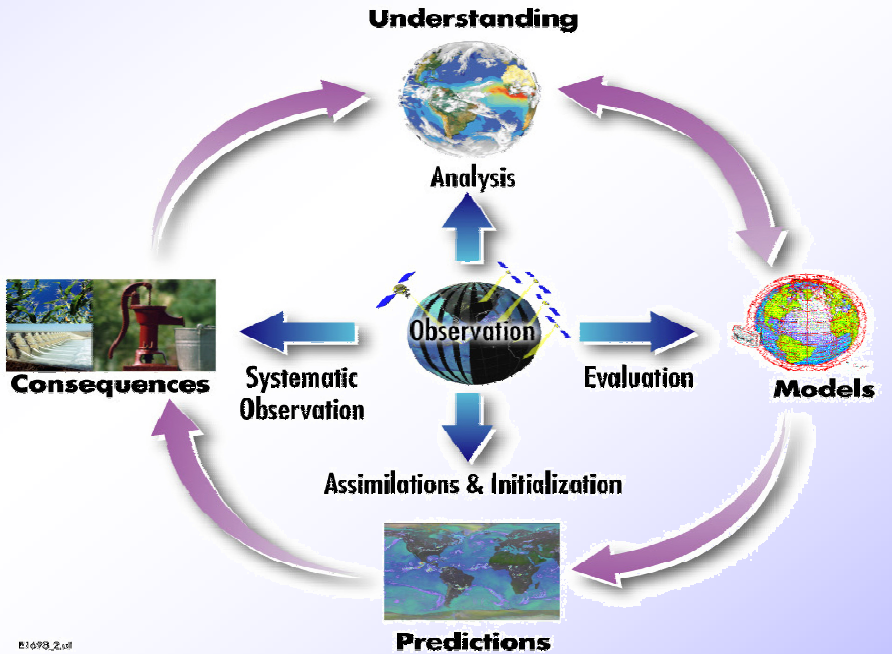
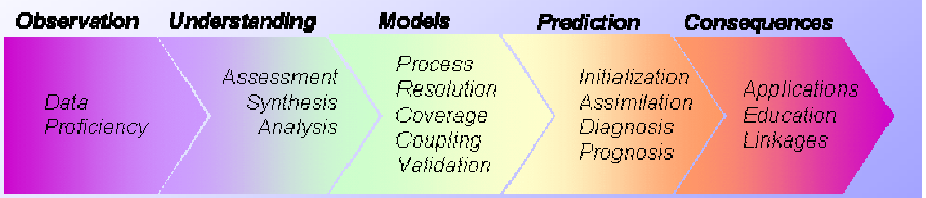

Earth Science Enterprise
National Aeronautics and Space Administration
NASA Energy and Water cycle Study Road Map
DRAFT Unofficial Version (4.22.2004)
Knowledge Base
NASA ENERGY AND WATER CYCLE STUDY
NEWS
Focus Area Linkages
C = Carbon
CVAWS = Climate variability
A = Atmospheric composition
W = Weather
S = Surface & interior
T = Technology development
= Field campaign
= Funded = Unfunded
Focus Area Challenge:
Document and enable improved, observation-based water and energy cycle consequence predictions (floods and droughts) of earth system variability and change
Address the ESE vision; deliver and evaluate system
Phase 3 Deliverables:
• Dataset gaps filled and extended
• Intensive prediction system testing
• Prediction system delivery
APPLICATION:
• Improved water & energy cycle forecasts for use in decision support systems
Predict consequences of climate change
Global hydrologic warning system T
Demonstrate useful predictions TWV
ANALYSIS & PREDICTION:
• Understand variability in stores and fluxes
• Accurate cloud prediction
• Improve latent heating & convection models
Reprocess combined observation record V
Demonstrate prediction capacity WV
Full end-to-end system test T
OBSERVATION:
•Quantify mean state, variability, and extremes of the water & energy cycles
•Flux, transport, and storage rate quantification
Comprehensive W&E cycle data management and retrieval system T
Coordinated W & E system T
Address deficiencies and build prediction system
Phase 2 Deliverables:
• Fix model problems with new observations
• New measurement approaches developed
• End-to-end prediction system developed
Observations used in planning
Test prediction of extremes WV
Develop application metrics
Enhanced RT models TVW
Improved physics CVW Model convergence
Super-parameterization T TWV
Multi-platform analysis T
Advanced multi-platform retrievals T
Experimental W&E observation system T
First Coordinated W&E Obs WVC Cold seasons T
GPM AQUARIUS HYDROS T Surface water T
Exploiting current capabilities and preparing for the future
Phase 1 Deliverables:
• First coordinated global W&E description
• Current prediction system evaluation
• Identify required system improvements
Application
Selected demonstrations
Climatology baselines V
Establish requirements T
Prediction
Land-cloud model CVAW
Multi-platform analysis T Physics-based modeling T
New climate datasets V OSSEs
Observation
Advanced Analysis T
TRMM TERRA AQUA GRACE ICESAT SCWAV
AURA CloudSAT CALIPSO VAW
Systematic observations of water and energy cycle including national and international partners
2004 IPCC Report 2006 2008 IPCC Report 2010 2012 IPCC Report 2014 2016 IPCC Report 2018

Prediction: Status/Capabilities Summary

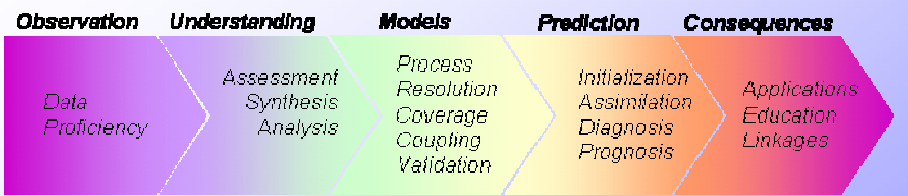
- Models hold considerable promise for “full environmental prediction”, but the limits to such prediction have yet to be comprehensively established.
- Data collection necessary to evaluate model results presents many challenges.
- Uncertainties resulting from either model deficiencies or observational data cannot be resolved.





NEWS Prediction Needs

- **Concurrent need for accurate long time series of observed fields and model simulation/prediction experiments**
  - **Improve the representation (parameterization) or simulation (prediction) across many timescales:**
    - **hours/days (hazard warnings)**
    - **week and months/seasons (for resource management)**
    - **or longer (for determining the impacts of global climate change).**
- **A wealth of satellite data has and will become available, need to position climate models to use it.**



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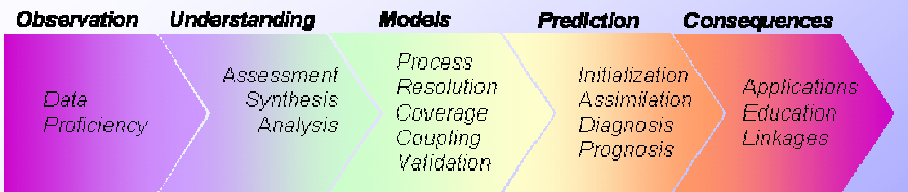
NEWS

NEWS Prediction Needs

- Model error propagation needed for assigning assimilation weights, is not quantitatively known. The overall implication is that both ***our observed and theoretical bases of climate predictability are still in question.***

- Central scientific challenge for NEWS will be to ***improve the fidelity of sub-grid scale, parameterized processes in coupled regional and global models*** so that physical feedbacks in the climate system are adequately represented.

- The notion that these energy and water processes can be parameterized to the extent needed remains an open question



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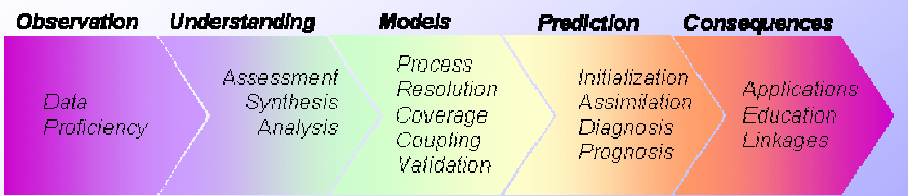
NEWS team kick-off meeting, September 7-9 2005

NEWS Prediction Needs

- "Super-parameterization" has not been comprehensively tested for seasonal-interannual prediction, and could also be applied to coupled climate models for climate change projections.

- On the longer term, the fundamentals of global models need to be improved (dynamics, physics, parameterizations etc.).
  - better understanding of microphysical processes via observational experiments and modeling studies.

- On the short term, improve prediction skills of water/energy cycle parameters in order to facilitate the delivery of applications products for water resource management (among other users).



NASA ENERGY AND WATER CYCLE STUDY
NEWS

Prediction Milestones: Key Elements

Phase 1: Exploiting Current Capabilities and Preparing for the Future

- ***Develop and test advanced energy and water data assimilation systems*** that ingest relevant atmospheric and hydrologic measurements and
- ***Determine initial values*** for regional to global model predictions of variations or change in the global precipitation and hydrologic regimes.
- Conduct quantitative evaluations of ***differences among global model predictions*** of the energy and water cycle over seasonal to decadal time scales, and investigate the causes for such differences.
- Establish ***performance metrics for energy and water cycle predictions*** taking into account the limits of predictability of atmospheric and hydrologic variables over a range of space- and time-scales, from regional to global, and from weather time-scale to climate change.

Phase 2: Integrating Essential Improvements into the Observation-Prediction System

- Assess ***similarities and differences between model climate variability on short timescales and forced responses*** of models on longer time scales
- Determine most ***informative model products for predicting water supply***
- ***Assemble experimental end-to-end energy and water cycle prediction system*** from observations to data assimilation, model initialization and prediction, to assessments of hydrological consequences and decision support systems

Phase 3: Completing and Validating the Water Cycle Prediction System

- ***Produce a fully interactive global climate system*** model that characterizes the complete energy/water cycle
- Construct a ***comprehensive energy and water data assimilation*** and prediction system
- ***Conduct a full end-to-end test*** of the prediction system against the past 30 to 50 year observational record… including the ability to predict extreme hydrologic events, out to decadal timscales.

Overall Prediction Achievements

- The "ultimate demonstration" of NEWS scientific advances:
  - Development of a new generation of models that account for all required physical parameters in the climate system.
  - Successful testing on decadal or longer model (hindcast) predictions against past and current climatological records.

- Integrating NEWS-generated advances in the representation of energy and water processes into consistent GCM frameworks

- Building a *comprehensive energy and water data assimilation and prediction system* that explicitly predicts the significant space- and time-scales of the energy and water cycle.

ROSES NEWS Prediction/Predictability

- Employ novel methods with advanced statistical analyses to quantify and diagnose *observed* predictability in the global water and energy cycles and *corresponding model fidelity and capability*.
- *Use observational and model data at a hierarchy of spatio-temporal detail* (starting at the most important, fundamental, or resolvable scales and progressing towards the global scale)
- Diagnose predictability under a consistent framework by *characterizing memories, pathways, and feedbacks.*
- Investigations should also aim to quantify and separate the 'unpredictable' (noise) and 'predictable' *observed* variations of key water and energy cycle quantities
- Evaluation of these *metrics among a hierarchy of model complexity and detail*. Model experiments should also be formulated such that an overall impact assessment of unresolved scales (i.e. clouds, radiation, convection) of global models could be made.
- Estimates of *observational uncertainty that are applied to uncertainty in predictability* characterizations are encouraged.